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ABSTRACT

Data from national and local studies have shown declines: (1) in the quality and quantity of mathematics and science instruction over the past 20 years; (2) in student enrollment in these subjects; (3) in student scores on standardized mathematics and science tests; and (4) in course offerings and enrollment in such foreign languages as German. Ways of addressing these problems include such approaches as upgrading teacher salary schedules, utilizing instructional strategies that emphasize problem-solving rather than rote learning, and developing technology-enhanced courses. It is this latter approach, the enhancement of existing instructional materials through utilization of educational technology (particularly through computer assisted instruction), that is proposed as a powerful means to improving science, mathematics, and foreign language instruction. The development of technology-enhanced mathematics and science courses is discussed, outlining the components of and activities in the development of such courses. Activities in identifying technology-based enhancements to support foreign language instruction are also discussed. Costs for implementing an individualized physics course for five students are included. (JN)

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SUPPORTING IMPROVEMENT OF INSTRUCTION IN SCIENCE, MATHEMATICS AND FOREIGN LANGUAGE INSTRUCTION

Discussion Draft

Prepared for the Chief State School Officers
of the Northwest and Pacific

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The Problem

Data emerging from both national and local studies indicate that the quality and quantity of mathematics and science instruction have been declining steadily over the past 20 years. Investigations at the national level reveal a shortage of qualified teachers at the high school level, with 43 states reporting mathematics teacher shortages, 42 states experiencing a shortage of physics teachers, and numerous states reporting teacher shortages in chemistry, earth science and biology. National studies further reveal that half of the newly-employed science and mathematics teachers in 1982-82 were hired on an "emergency basis" and were not qualified to teach these subjects. Generally speaking, mathematics and science teachers across the nation do not engage in ongoing inservice activities, and enrollment of students in preservice mathematics and science teacher preparation programs has evidenced a steady decline.

Student enrollment in mathematics and science courses has likewise declined. While enrollment in courses for many of the sciences is higher in private schools than in public schools, fewer students in both settings are enrolled in science and mathematics courses than at any previous time. Regional and national studies of enrollment have also demonstrated that male enrollment in mathematics and science courses is still far greater than female enrollment.

Two other major concerns regarding what has been called the "20-year erosion" of science and mathematics instruction in the U.S. include the steady decline in student scores on standardized math and science tests,

and the related--and perhaps even more disturbing--problem of lagging industrial productivity brought about by shortages of workers with adequate technical training.

Local data are congruent with findings at the national and regional levels. Figures from the Oregon State Department of Education show decreases in student enrollment in mathematics and science courses together with a decrease in the number of teachers certified and placed. Ray Thiess, science education specialist for the Oregon Department of Eduation, was recently quoted by The Oregonian, saying that "...industry moves ahead--the more years that go by, the wider the gap (between our technological society and provision of adequate science and math education) will become." Thiess called attention to the need for a change in approach to instruction in mathematics and science: "One of the biggest problems...is that they're still being subjected to rote learning--coming up with the 'right' answer. Our students are very poor problem solvers. And that's why our science programs need to be overhauled."

Another major concern of educators and others interested in the state of U.S. education in the current situation regarding course offerings and student enrollment in foreign language studies indicate that German has "nearly vanished" as a subject in all types of schools, and that French is now infrequently taken by public school students. Additionally, only a small minority of students continue to take foreign language instruction past the second year--in any foreign language, in any type of school. And fewer schools offer a rich and ongoing foreign language curriculum than in years past. As pointed out in a publication by the

National Opinion Research Center in 1981, "...this shows very little attention to foreign languages in an era in which there is more international mobility and communication than ever before."

Improvement Strategies

Approaches to addressing the lack of qualified mathematics and science teachers include such options as upgrading salary schedules or providing differential pay for such teachers, so as to make education competitive with industry in recruiting and maintaining qualified persons; re-establishing special summer institutes and workshops; and providing needed staff development activities at the state and local education agency levels, so that the skills of underqualified teachers can be upgraded and those of other teachers can be furthered. Utilization of personnel from industry as part-time teachers has been proposed, as has the provision of low-interest loans to those who wish to prepare as teachers in mathematics, science and the foreign languages.

Perhaps the most powerful strategies for improving instruction are those which focus directly on instruction of students in the classroom. Enhancement of instructional approaches at the fifth and sixth grade levels is seen as advisable, as this is the time when many students--and particularly girls--start to become dissuaded from entering scientific or mathematics fields. It also appears necessary to give greater instructional emphases to problem solving skills, as opposed to rote learning.

Enhancement of existing instructional materials through utilization of technology--particularly computer-assisted instruction--is proposed as a singularly powerful means to improving math and science instruction.

Computer-assisted instruction, for example, can help students develop logical thinking and problem-solving strategies and eliminate many tedious computational tasks, thus permitting students to understand more quickly the derivation and use of equations and can provide ready access to information not easily obtainable through other means. Further, computers and video equipment can provide, in the form of simulations and demonstrations, opportunities to apply learnings in ways that cannot reasonably be duplicated in average school laboratories or classrooms.

Technology-assisted instruction (including CAI, audio and video materials) can also provide support for the classroom teacher. By combining the best of what is available in mathematics, science or foreign language instruction technologically with a careful analysis of existing textual materials, a sound instructional program can be developed at a level of completeness useable by teachers with a variable range of content skill and knowledge. It is this approach that NWREL proposes for consideration.

Each technology-enhanced course will be developed by combining a detailed textbook analysis and matching process with the Tri-County Course Goals and the resources of RICE and MicroSIFT.

The Tri-County course goals establish clear, measurable student objectives for the selected content area. Adopted text materials for that content area are subjected to detailed analysis in regard to adequacy of instruction for the established student objectives. Results of the analysis process then serve to guide the identification and selection of technology-based materials which will supplement and enhance the textual materials. The analysis process also yields information on <u>when</u> and <u>how</u> such supplemental materials should be used in conjunction

with the text, and, hence, make possible development of a systematic, individualized learning approach.

Development of Technology-Enhanced Courses: Mathematics and Science

The K-12 Course Goals and findings from the textbook analysis process will be used to establish a detailed development plan for each technology-enhanced course. This development plan will also serve as the basis for screening and selection of existing software, audio/video and print materials to be incorporated into the learning system.

MicroSIFT and RICE are already-existing mechanisms for supporting the search and screening of software. These efforts put NWREL in touch with virtually every producer of microcomputer courseware, both commercial and noncommercial.

Based on the findings of MicroSIFT and RICE search and screening processes, specific computer-based programs and materials will be identified. Audio and video programs and materials such as tapes, films, videocassettes, slides and filmstrips will also be identified, as will existing instructional television programs.

Development of new or revised materials to fill gaps among existing software, other materials and the text-based instruction will be planned. Specific strategies, adaptations and modes of presentation will be identified to insure that the technology-enhanced course can be utilized effectively by individual students.

Use of a computerized instructional management system designed to match course objectives and activities is recommended. Such a system can facilitate management of student progress, assessment of mastery of specified learning objectives, and necessary record keeping. Use of a

computerized management system would ensure systematic, individualized student use of course materials and provide needed instructional support for supervisory teachers.

In summary, the proposed technology-enhanced courses would include the followng components:

- o Print
  - -- Commercially produced textbook and laboratory manual
  - -- Student Guide, worksheets, keys
  - -- Materials to accompany audio/video programs
- o Computer
  - -- Computer-assisted instruction (drill, simulation, problem-solving)
  - -- Computer-managed instruction
    - --- Assessment and testing
    - --- Objective-based student records
    - --- Tracking of students (placement; progression)
- o Audio/Video
  - -- Instructional materials (introductory, explanatory, motivational)
  - -- Laboratory supplements (demonstrations, simulations, open-ended)

Activities in the development of an individualized technology-enhanced course will include:

- o Development of a detailed course design
- o Search and selection of existing materials and software
- o Adaptation and/or creation of Student Guide materials (e.g., directions pages, background information, student progress charts, directions for experiments/laboratory activities, introductions to computer, audio/video activities)

- o Adaptation and/or creation of other print materials (e.g., worksheets and keys)
- o Incorporation, adaptation or development of audio/video materials and accompanying print materials
- o Incorporation, adaptation and/or development of computer activities and tests
- o Incorporation and/or development of student projects
- o Incorporation and/or development of a computerized instructional management system
- o Compilation and production of Student Guides and other materials (software, print, audio/video) into a learning package
- o Distribution and pilot testing
- o Compilation of pilot test results
- o Revision

Development Time and Cost. Development and production of one technology-enhanced course in upper level mathematics or science, in sufficient quantity (100 copies) for pilot testing, would range in cost from $75,000 - $100,000. The time period needed for development would range from 8-10 months.

Assistance in Identifying Technology-based Enhancements to Support Foreign Language Instruction

Because numerous courses and technology packages exist for foreign language instruction, direct assistance is proposed as a means for supporting improved foreign language instruction. Such assistance will be provided to state and local education agencies in identifying, analyzing and selecting relevant technology-based packages for supporting foreign language instruction. Services would include: assistance in delineating course goals and objectives; identification, analysis and selection of appropriate software, video, audio or ITV packages and

materials; assistance in development of a plan for implementation, and if desired, follow-up assistance with implementation.

Technical Assistance Time and Cost. Direct assistance to be provided to school sites for improvement of foreign language instruction would be established according to need (generally three to eight days) and would range in cost from $1,200 - $3,200.

Implementation Costs. Although per student expense of implementation of a technology-enhanced course will vary, the following scenario gives an indication of both potential use strategies and cost factors.

School District 72E, a rural district with one high school, wishes to offer a physics course for five students. The current staff does not include a physics teacher, nor is there sufficient demand to support hiring such a specialist. The chemistry teacher has indicated a willingness to provide backup support on an occasional basis to physics students enrolled in an individualized program--probably at a maximum of one hour per week during study hall. Hence, there will be little or no direct staff cost for implementing the program.

Students enrolled in the technology-enhanced, individualized physics course will use the Learning Center in the school library. The Center, supervised by one staff member and a volunteer aide, is equipped with individual cassette recorder/players, a videocassette player and monitor, and two fully-configured Apple II microcomputers.

Initial costs of implementing the individualized physics course for the five students will include:

5 physics texts at $20.00 each	$ 100.00
5 laboratory manuals @ $12.50 each	62.50
1 Teachers' edition of text and manual	35.00
5 Student Guides (non-consumable) @ $3.50 each	17.5
1 master set of student worksheets (duplicate as needed)	5.00
2 sets physics audiotapes @ $30.00 each	60.00
1 set disks; computer-management system	30.00
2 boxes ten blank disks (student disks) @ $15.00 per box	30.00
1 set physics videocassettes (3 @ $87.50 each)	262.50
1 set commercial software (12 disks; individual prices vary)	550.00
TOTAL	$1153.00

The cost per student for the first year of implementation is approximately $231.00; per student costs for subsequent years would be limited to replacement of consumable materials.

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